NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1003-20-4891

May 5, 1959

NBS REPORT
6401

CAPACITY TESTS OF A REMOTE AIR-COOLED
SIZE B, CLASS I REFRIGERANT CONDENSER

MANUFACTURED BY
THERMO KING CORPORATION

by

F. J. J. Drapeau and C. W. Phillips
Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

Mechanical Engineering Division
Headquarters,
Quartermaster Research and Engineering Command
Natick, Massachusetts

IMPORTANT NOTICE

NATIONAL BUREAU O
intended for use within
to additional evaluation
listing of this Report, ei
the Office of the Directo
however, by the Governi
to reproduce additional

Approved for public release by the Director of the National Institute of Standards and Technology (NIST) on October 9, 2015.

or progress accounting documents
is formally published it is subjected
ting, reproduction, or open-literature
rmission is obtained in writing from
C. Such permission is not needed,
cally prepared if that agency wishes

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

CAPACITY TESTS OF A REMOTE AIR-COOLED SIZE B, CLASS I REFRIGERANT CONDENSER

MANUFACTURED BY
THERMO KING CORPORATION

by

F. J. J. Drapeau and C. W. Phillips

1. Introduction

Capacity tests were made of a remote air-cooled refrigerant condenser, Size B, Class I, manufactured by the Thermo King Corporation of Minneapolis, Minnesota. This specimen was identified for testing purposes as NBS 178-58.

The tests were made with an apparatus conforming in most details to that described in the proposed ASRE Standard, PS 2.4, for remote air-cooled condensers. This apparatus provided a means for measuring the heat transfer capacity of this specimen by the psychrometric method and by the refrigerant flow method.

2. Test Procedure

Capacity tests were made at two values of saturation temperature of the refrigerant vapor entering the condenser, following the procedure and test conditions set forth in ASRE PS 2.4. At the higher saturation temperature of 130°F, tests were made at three air flow rates; namely, at the free discharge capacity of the fan, and at one lower and one higher value, ranging from 2950 cfm to 4100 cfm. In addition, one test was made at the high ambient temperature of 110°F, established as a standard for QMR&E application.

These tests are a part of a series of tests planned under the Condenser Standardization Project, QMREL-M P.O. 57-26, to determine the possibility of standardizing air-cooled condenser performance on the basis of maximum overall dimensions and minimum air flow rate.

This condenser was tested with a Torrington propeller fan with air delivery capacity meeting the minimum requirement of the QMR&E Purchase Description dated March 22, 1957. However,

this condenser did not come equipped with a shroud or bellmouth orifice plate. To facilitate the tests, these parts were fabricated by the Sheet Metal Shop at NBS. A bellmouth radius of approximately 3/8", somewhat less than the QMR&E established minimum of 1/2"; and an orifice diameter varying from the QMR&E specified value of 24 1/2" by not more than ± 1/8" were constructed for the tests.

3. Test Results

The results obtained and the dimensional data describing this condenser are attached. Fig. 1 indicates the shape and tube arrangement, and uses letter symbols to identify the dimensions of the specimen as summarized in Table 1. Table 1 describes the materials and construction of the condenser and lists significant dimensions of coil, fins, and complete unit.

Table 2 summarizes the test data and the heat rejection capacity ratings and heat transfer coefficients computed therefrom. Fig. 2 is a pressure-enthalpy diagram labeled with the symbols used in the proposed ASRE Standard, PS 2.4. This diagram indicates the changes in state conditions of the refrigerant occurring between the condenser inlet and outlet.

In order to provide a further means for comparing the performance of the various arrangements of tubes, tube arrangements, fins, etc., of the several condensers in this test program, two additional coefficients, which can be considered as Items 24 and 25 of Table 2, are as follows:

Item 24 Heat Rejection per Unit of Total Surface Area per Degree F Log Mean Temperature Difference, Btu/hr $(ft)^2(°F)$

Item 25 Heat Rejection per Unit of Total Surface Area per Degree F Log Mean Temperature Difference per cfm of Standard Air, $Btu/hr(ft)^2(°F)(cfm)$

Addition to Table 2

Item	ASRE High Sat'n. Temp. High	ASRE High Sat'n. Temp. Free Discharge	ASRE High Sat'n. Temp. Low	ASRE Low Sat'n. Temp.	QMR&E High Ambient Temp.
24	7.77	7.18	6.74	5.81	7.30
25	.00207	.00207	.00250	.00175	.00230

It should be noted that the heat rejection capacity of this condenser at the QMR&E High Ambient Temperature conditions was 102.5 percent of the required value of 35,600 Btu per hour.

USCOMM-NBS-DC

CONDENSER SPECIMEN

MFR. Thermo King Corp. | NBS NO. 178-58 | SIZE - B | CLASS - 1

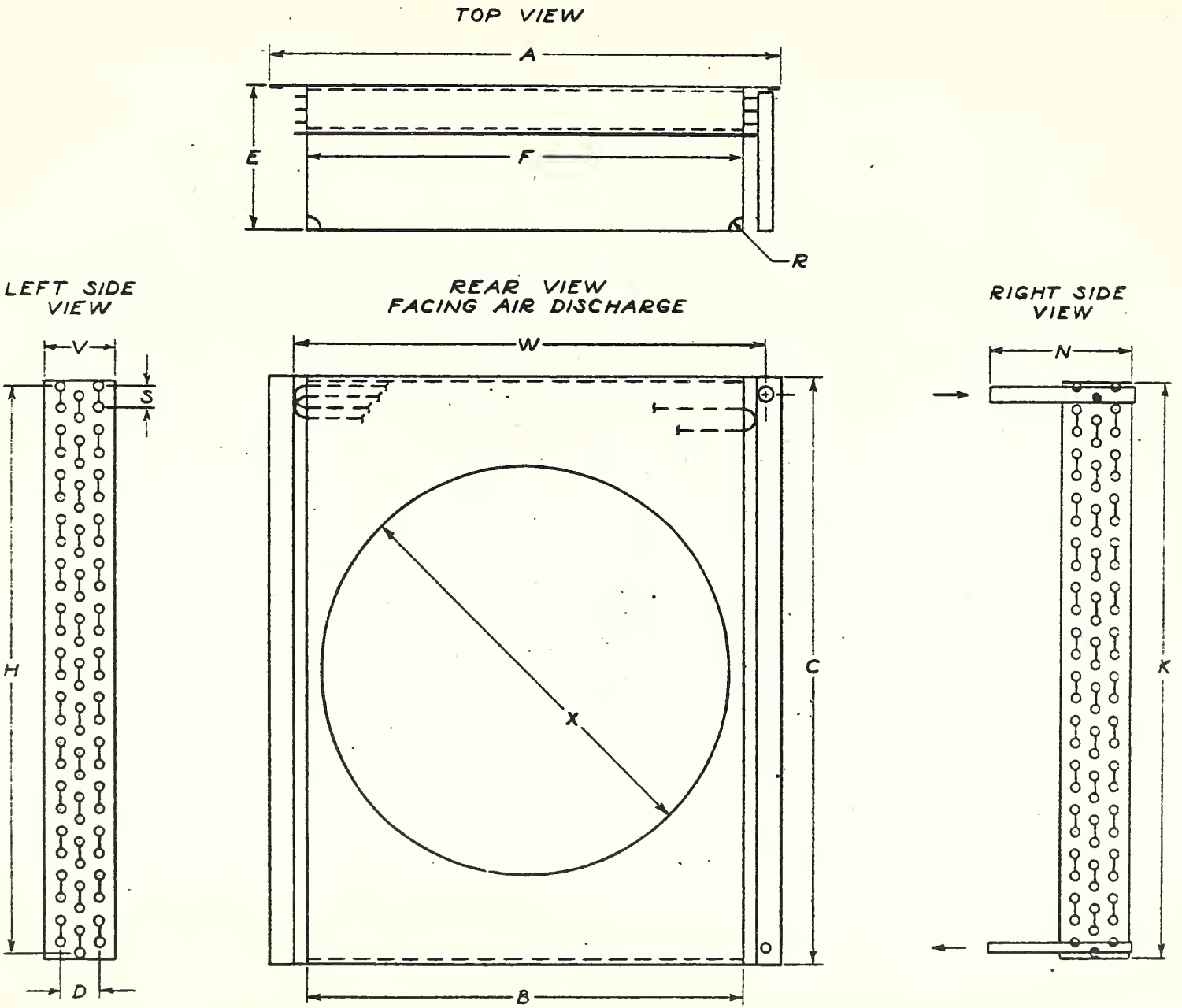
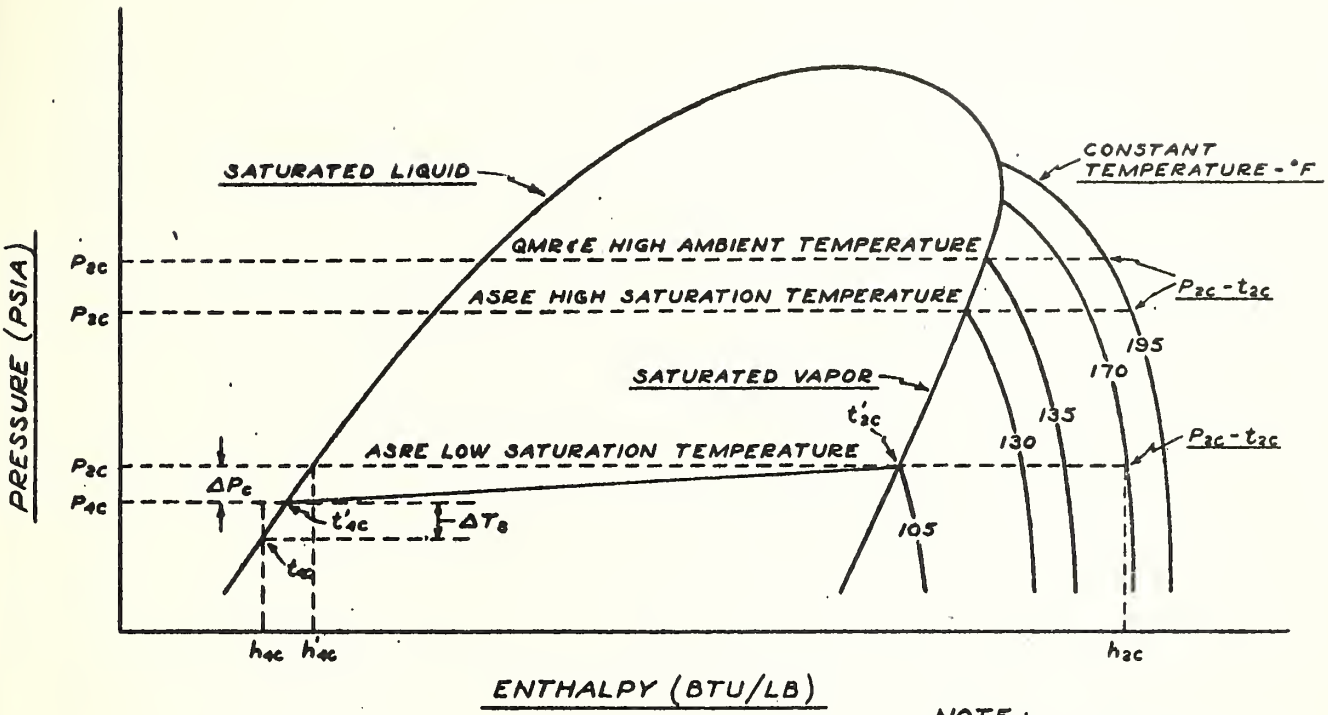


Fig 1

PRESSURE - ENTHALPY DIAGRAM

NO SCALE



NOTE :
LABELED IN ACCORDANCE WITH ASRE PS 2.4

CONDENSER SPECIMEN DIAGRAM

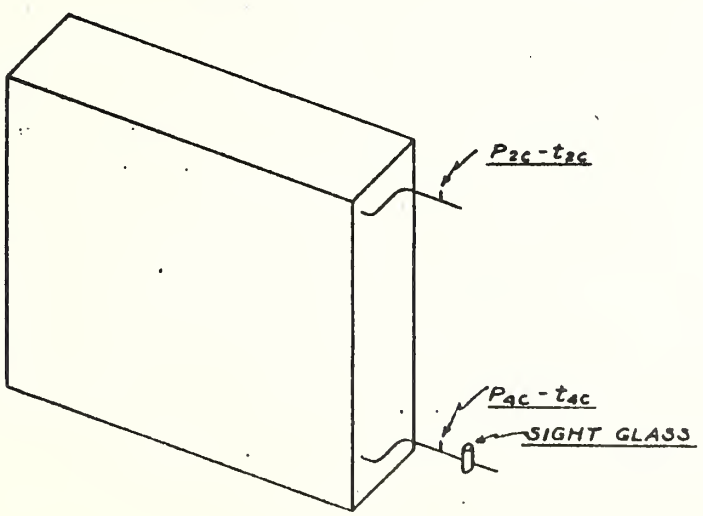


Fig 2

CONDENSER SPECIMEN

MFR. Thermo King, Corp. — SIZE - B

NBS NO. 178-58 — CLASS - 1

ITEM		PROPERTY	REMARKS
COIL TUBE CHARACTERISTICS			
1 MATERIAL		Copper	Type L
2 NUMBER OF ROWS DEEP		3	
3 NUMBER OF TUBES HIGH		26	
4 NUMBER OF CIRCUITS IN PARALLEL		3	
5 NUMBER OF TUBES PER CIRCUIT		26	
6 TUBE DIAMETER, O.D., IN.		1/2	
7 TUBE WALL THICKNESS, IN.		0.042	
8 TUBE RETURN BEND DIAMETER, O.D., IN.		1/2	
9 GAS INLET CONNECTION DIAM., O.D., IN.		7/8	
10 LIQUID OUTLET CONN. DIAMETER, O.D, IN.		5/8	
11 VERTICAL TUBE SPACING, IN.	S	1.3	
12 PRIMARY SURFACE AREA, SQ. FT.		23.2	
COIL FIN CHARACTERISTICS			
1 MATERIAL		Aluminum	
2 TYPE OF FIN		Flat	Rolled Collar
3 FIN SPACING, PER INCH		8	191 Fins
4 FIN THICKNESS, IN.		0.015	
5 SECONDARY SURFACE AREA, SQ. FT.		238.3	
COIL DIMENSIONS			
1 FINNED HEIGHT, IN.	K	32.5	
2 FINNED WIDTH, IN.	F	27.0	
3 FINNED DEPTH, IN.	V	3.0	
4 COIL HEIGHT, IN.	H	31.9	
5 COIL WIDTH, IN.	W	29.5	
6 COIL DEPTH, IN.	D	2.0	
7 COIL DEPTH, OVERALL, IN.	N	10.8	
8 FACE AREA, SQ. FT.		6.2	
9 TOTAL SURFACE AREA, SQ. FT.		261.5	
OVERALL CONDENSER DIMENSIONS			
1 WIDTH, OVERALL, IN.	A	32.5	
2 WIDTH, SHROUD, IN.	B	27.5	Manufactured by NBS
3 HEIGHT, IN.	C	34.1	
4 DEPTH, IN.	E	11.0	
5 BELLMOUTH ORIFICE DIAMETER, IN.	X	24.5	Manufactured by NBS
6 BELLMOUTH RADIUS, IN.	R	3/8	Manufactured by NBS

Table 1

CONDENSER SPECIMEN

MFR. Thermo King Corp. NBS NO. 178-58 SIZE - B CLASS - 1

AIR CIRCULATING EQUIPMENT AND REFRIGERANT USED

FAN MFR. — Torrington
FAN SERIAL NO. — E-2420-4
FAN SPEED — 1140
MOTOR HP RATING — 0.500
REFRIGERANT — Freon-12

ITEM			ASRE HIGH SATURATION TEMPERATURE				ASRE LOW SATURATION TEMPERATURE		QMR&E HIGH AMBIENT TEMPERATURE	
			STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM HIGH	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCH.	OBSERVED CONDITION AIR FLOW RATE CFM LOW	STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCHARGE	STANDARD CONDITION	OBSERVED CONDITION AIR FLOW RATE CFM FREE DISCHARGE
1. BAROMETRIC PRESSURE	P_{ab}	"H_g	29.921	29.73	29.81	29.92	29.921	29.29	29.921	29.62
2. DRY BULB TEMPERATURE OF AIR ENTERING COIL	t_{ae}	°F	95	95.0	95.2	95.0	95	95.0	110	110.0
3. WET BULB TEMPERATURE OF AIR ENTERING COIL	t'_{ae}	°F	75 ± 5	75.0	75.2	77.0	75 ± 5	75.2		74.2
4. DRY BULB TEMPERATURE OF AMBIENT AIR	t_{ae}	°F	95	95.0	95.2	95.0	95	95.0	110	110.0
5. SATURATION TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t'_{ac}	°F	130	130.6	130.0	129.8	105	105.4	135	135.5
6. SUPERHEAT TEMPERATURE OF ENTERING REFRIGERANT VAPOR	t_{ac}	°F	195 ± 10	194.7	194.6	195.2	170 ± 10	172.0		195.1
			AIR FLOW METHOD				AIR FLOW METHOD			
7. NOZZLE AIR AND WATER VAPOR MIXTURE FLOW RATE	Q_{ad}	CFM		4100	3620	2950		3610		3540
8. TOTAL HEAT REJECTION CAPACITY	q_{tc}	BTUH		57650	51250	46500		13850		37850
			REFRIGERANT FLOW METHOD				REFRIGERANT FLOW METHOD			
9. REFRIGERANT FLOW RATE	W_r	lb/min		14.47	12.95	11.73		3.29		9.79
10. CONDENSER COIL INTERNAL PRESSURE DROP	ΔP_c	PSI		3.12	2.45	2.44		0.55		1.33
11. SUBCOOLING OF LEAVING REFRIGERANT LIQUID	ΔT_s	°F	10° MAX.	6.6	3.7	3.8	5° MAX.	1.0		3.7
12. TOTAL HEAT REJECTION CAPACITY	q_{tr}	BTUH		56500	50050	45500		13300		36750
			RATINGS				RATINGS			
13. TOTAL HEAT REJECTION	q_{tR}	BTUH		56100	50900	46300		13050	35600	36500
14. CONDENSING HEAT REJECTION	q_{cR}	BTUH		54350	49950	45400		13000		35900
15. SUBCOOLING HEAT REJECTION	q_{sR}	BTUH		1750	950	900		50		600
16. AIR FLOW RATE	Q_R	CFM		3750	3320	2700		3320		3170
17. CONDENSER COIL EXTERNAL RESISTANCE	P_{as}	"H_2O		0.24	0.20	0.13		0.20		0.20
18. FAN MOTOR POWER	P_{fm}	WATTS		450	520	600		520		520
19. FAN BRAKE HORSEPOWER	P	BHP		-	-	-		-		-
20. HEAT REJECTION PER UNIT PRIMARY SURFACE AREA		BTUH/SF		2418	2194	1996		563		1573
21. HEAT REJECTION PER UNIT SECONDARY SURFACE AREA		BTUH/SF		235.4	213.6	194.3		54.8		153.2
22. HEAT REJECTION PER UNIT TOTAL SURFACE AREA		BTUH/SF		214.5	194.6	177.1		49.9		139.6
23. HEAT REJECTION PER CFM		BTUH		15.0	15.3	17.1		3.9		11.5

Table 2